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1. INTRODUCTION

- 1.1. Over the past several decades, a relatively new construction feature has become prevalent throughout all areas of the United States. With architects and builders seeking greater efficiency via lower material and labor costs, older buildings using traditional, ordinary/wood frame construction have been renovated or demolished and replaced with structures using lightweight building materials. The impact of this lightweight construction from a fire service operational and safety standpoint is significant. In order to adapt to the potential change in conditions encountered at fires and emergencies in these types of buildings, an adjustment must be made in tactics and procedures.
- 1.2. This chapter will primarily focus on the construction features and operations in private dwellings constructed of lightweight materials. The private dwelling procedures found in other sections of these guidelines will apply to these lightweight buildings as well. Whenever applicable, however, the variations and safety precautions pertaining specifically to lightweight construction will be addressed.
- 1.3. In the past, builders of private dwellings, and other types of structures using wood frame/ordinary construction, did not know much about the failure points and strength testing of structural materials. To provide the necessary structural support and keep them from collapsing, buildings were designed with a built-in safety factor by increasing the size and mass of the load bearing structural elements. By contrast, in recent years, structural engineers have been able to utilize improved technology to more precisely calculate the collapse points of less costly building materials. With greater frequency, private dwellings are now being constructed with smaller and lighter weight, engineered building materials in preference to the larger, heavier dimensional lumber found in older construction.
- 1.4. In the absence of increased mass, the strength of a lightweight system is obtained through the interconnection of multiple structural components providing support in compression and tension. Furthermore, the decrease in size and mass of the individual structural


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components will impact the stability of all other structural components; if one fails, the others may fail as well.


- 1.5. In any building construction, the critical area subject to failure as a result of fire is the point of connection.
- 1.6. For fires in “**traditional**” private dwellings built of ordinary/wood frame construction, early collapse is not a primary consideration. At these types of buildings, depending on the duration and intensity of fire, the size of the structural components, and the type of construction involved, the amount of time before collapse occurs is generally estimated to be an hour. However, when there is no ceiling to provide protection, therefore exposing structural components, failure can occur within 20 minutes.
- 1.7. In private dwellings constructed with **lightweight materials**, when fire extends from the building's contents to its structural components, collapse may occur within 5 to 10 minutes. (Figure 1)



Figure 1

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- 1.8. Collapse in lightweight structures can occur suddenly, and with little or no warning signs.
Collapse is always the primary consideration in buildings constructed with lightweight materials.
- 1.9. Experience has shown that structural collapses have occurred in buildings where the magnitude of fire was relatively small. Therefore, positioning the 1st hoseline for early extinguishment or control of a contents fire that has not extended to the structural components is of paramount importance.
- 1.10. Lightweight construction often provides for the creation of large rooms. Areas unsupported by columns with spans greater than 25' are generally an indication that lightweight construction is present. The collapse potential in a "wide-open" room of this type is greater than in a compartmented area that has interior walls. The most important factor to a safe and successful operation at these types of buildings is the identification of the presence of lightweight construction. It is critical that any member becoming aware of lightweight construction notify the Incident Commander (IC).
- 1.11. When lightweight components are exposed to fire or high heat, the IC shall be immediately notified. It may be necessary to remove members or suspend interior operations until further assessment of structural stability and collapse potential can be made.
- 1.12. Lightweight buildings under construction, within a Fire District, should be the subject of department familiarization drills. These drills should be used to obtain critical information for entry into pre-plans.

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2. CONSTRUCTION

2.1. General Construction Features:

2.1.1. Private dwellings with lightweight construction are generally 1-3 stories in height, and have either a flat or peaked roof. They are usually built over a crawl space or a cellar constructed of 8" cement block or poured concrete foundation. Some homes may have a full finished cellar. They may be found to be attached, semi-attached, or detached. Attached or semi-attached units are normally separated by a fire wall that may extend through the attic/cockloft.

2.1.2. General Construction Deficiencies:


- Inadequate fire stopping
- Improperly installed metal gang nails
- Inadequate bracing
- Out of plumb structural components
- Cracked or damaged truss components
- Unauthorized alterations
- Unprotected wood floor joists

2.1.3. A combination of both lightweight and ordinary construction may be used in the same structure (i.e. renovated private dwellings).

2.2. Specific Construction Features:

2.2.1. Interior walls – Typically constructed of 1/2" drywall supported by metal or wood studs. In attached structures, double 5/8"- 1" drywall is used on the partition walls between structures. When these fire-resistant barriers are compromised by shoddy workmanship or renovations, fire may extend into the structure where these lightweight materials are present.

2.2.2. Exterior walls – Various types of construction materials are used (e.g. wood, stone or brick veneer; stucco, sheet metal). The heavier type of exterior finishing products (stone or brick veneer) may be anchored to the structure with metal straps or wire

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mesh. These walls may potentially fail as one complete unit when exposed to fire and high heat.

- 2.2.3. Finished ceilings – May consist of 5/8” or 1/2” drywall. A trussloft is an enclosed area between floors and ceiling where open truss construction is found; however ceilings may not be present in basement/cellars. In some cases, the structure is built over a crawl space or cellar with an unprotected first floor support system.
- 2.2.4. Floors – Generally, the flooring used in lightweight construction is not as substantial as is found in ordinary construction. Vinyl flooring or carpeting is often installed over single-thickness plywood sheathing or oriented strand board (OSB). Floor coverings using cement board, lightweight concrete, nylon pile carpet and tile will retain heat under the floor making it more difficult to detect hot spots on the floor above the fire. These types of flooring may also give firefighters the false impression that they will provide enough support to operate above the fire area.
- 2.2.5. Roofs – Lightweight wood truss roofs may be flat or peaked. A large, open cockloft/attic is commonly found in either design.
- 2.2.6. The most common type of peaked roof found in lightweight construction is the open-web lightweight wood truss. In an ordinary peaked roof structure with dimensional lumber, the collapse of the roof rafters and roof deck may be supported by the ceiling beams below, thereby protecting firefighters operating on that floor. When a lightweight wood truss peaked roof is exposed to sufficient fire, the rafters (top chord of the truss), the roof decking, and ceiling joists (bottom chord of the truss) can be expected to collapse as one complete unit into the structure, exposing firefighters to falling and burning debris. (Figure 2)



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Figure 2

- 2.2.7. The cockloft/attic space found above the top floor ceiling is commonly used for electrical/plumbing utilities and HVAC ductwork. This area may also be used by occupants for storage, thus creating an additional live load that may lead to early collapse of the floor of the cockloft/attic. Entry to this space is often via a scuttle or a pull-down type staircase.
- 2.2.8. Roof decks found on both peaked and flat roofs are constructed with 3/8" or 1/2" plywood instead of the 3/4" plywood or 1-inch wood sheathing used in ordinary

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construction. Plywood burns rapidly, and will fail at a faster rate. Fires originating in, or extending to, the cockloft/attic space will quickly vent through the roof.


2.3. **Voids** – Voids for electrical/plumbing utilities may be found on any floor. Utilities may also be found in vertical voids which can run the height of the building. All voids and HVAC ductwork will create avenues for the spread of smoke, heat, and fire.

2.3.1. Fire-stopping (draft stopping) – installed above the ceiling is limited, resulting in an open space which could encompass the entire area of the building. In some areas, the Building Code requires lightweight constructed spaces between the ceiling and the floor above or the ceiling and roof above to be divided into approximately equal areas of 500 sq. ft. or less unless the building is equipped with an automatic sprinkler system.

2.3.2. In some larger private dwellings, the drywall ceiling may be installed several inches below the lightweight supporting members to provide for the running of utilities. This type of installation is more prevalent in cellars with wood I-beam and metal C-joist construction than the open web truss due to the lack of horizontal openings to run utilities. The result is a large open area between the ceiling and the joists, creating the potential for rapid fire spread and extension. (Figure 3)



Figure 3

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2.3.3. Decks/Balconies – Outside decks and balconies are often supported by lightweight joists extending through the exterior wall. Any cantilevered deck/balcony should be considered a serious collapse potential.

3. **TYPES OF LIGHTWEIGHT SYSTEMS**

There are many different types of lightweight systems in use today. This bulletin will address the four most common types of lightweight systems that may be encountered in private dwellings:

- Lightweight parallel chord truss
- Laminated wood I-beams
- Metal C-joists
- Composite truss

3.1. **Lightweight Parallel Chord Wood Truss**

This type of support system is made up of 2x3" or 2x4" wooden web and chord members connected with sheet metal gusset plates (also referred to as gang nails). Since these connections only penetrate 1/4" - 1/2" into the wooden truss member, the gang nails are the weakest point of the support system. When exposed to fire and/or high heat, failure at the point of connection should be expected before failure of the structural wood components.

When lightweight wood trusses are exposed to fire, high heat, or prolonged exposure to water, the gang nails may loosen and fail, causing the entire span of that particular truss section to fail. The surface-to-mass ratio of the wood trusses provides an abundant fuel source, and the air supply in the concealed truss void allows for rapid horizontal extension. Due to the open-web characteristic of the truss system, fire which has entered a ceiling (trussloft) or roof space (cockloft/attic) may likely affect all truss supports on that level, creating the potential for a large-scale collapse of the area supported by the affected trusses. (Figures 4 and 5)



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Figure 4



Figure 5

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Another type of open-web wood joist uses finger joints and glue to connect the web and the chords.

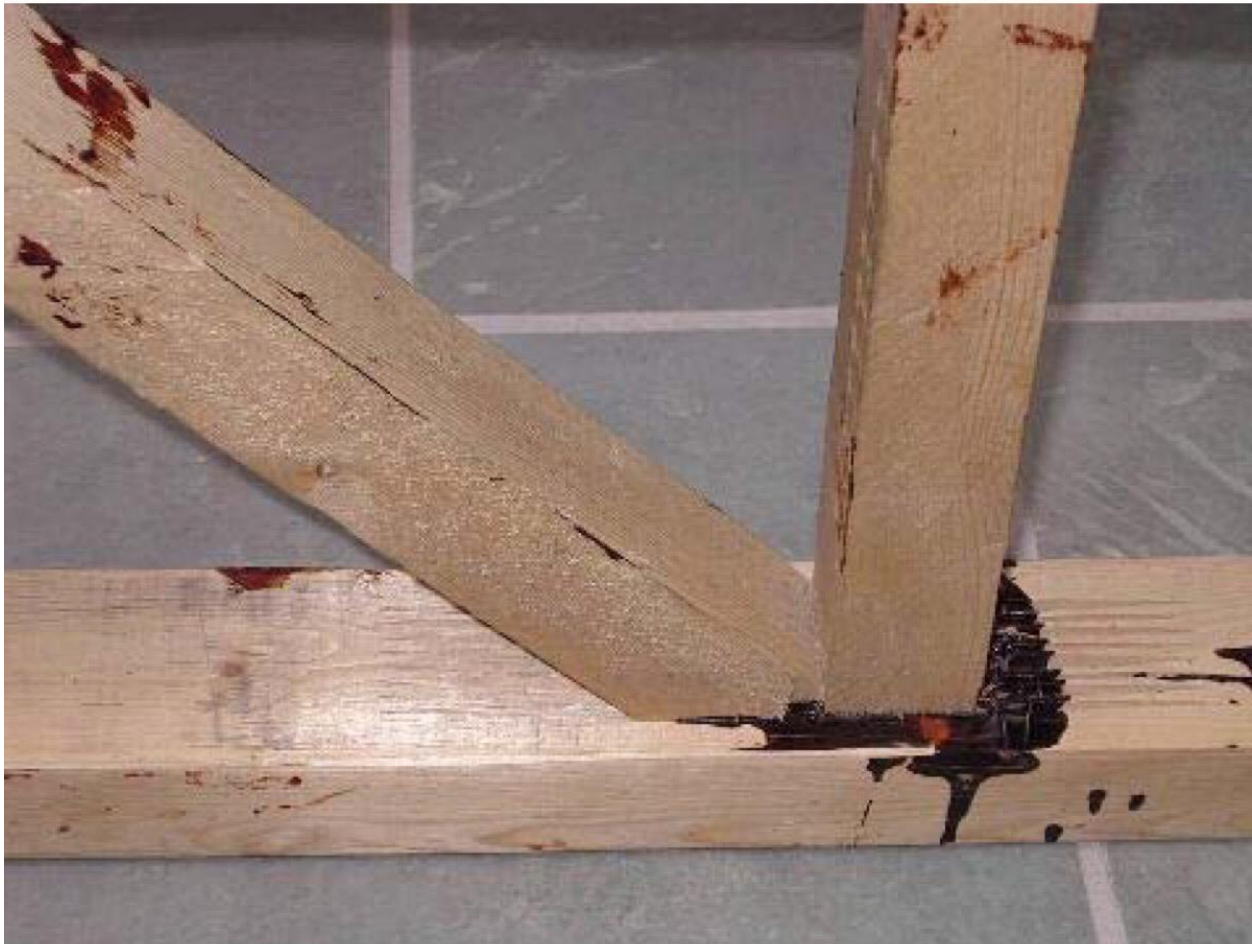



Figure 6

The finger joints are approximately $\frac{3}{4}$ " deep; and, similar to parallel cord wood truss without the metal gusset plate, these trusses can be expected to fail rapidly when exposed to fire and/or high heat. (Figure 6)


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3.2. Laminated Wood I-Beams

This type of support system is primarily comprised of 1/2" oriented strand board (OSB) or 3/8"- 1/2" plywood web members, and 2x3" or 2x4" wood flanges. The web is fitted and glued into a routed slot in the top and bottom flanges. In some cases, they may span lengths of over 60 feet. The strength of the beam is a function of the mass of the flange and the depth of the web. These beams are usually connected to load bearing walls with sheet metal joist hangers. These I-beams are pre-engineered, and may come with openings in the web to accommodate utilities. In other instances, builders will bore holes in the web for plumbing, electrical lines, and HVAC ductwork, thus compromising its strength. A fire-retardant material sprayed on the beam will tend to dry out the wood over time, making it brittle and further reducing its strength. Once the ignition temperature has been reached during a fire, a laminated wood I-beam will burn rapidly. The sheet metal brackets holding the beams in place may also fail when exposed to fire or high heat. (Figure 7)



Figure 7

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3.3. Metal C-Joists

This type of support system uses lightweight cold-formed steel joists to support the floors and/or roof. Although these joists are designed to replicate the dimensions of a 2x10" wood joist, they are engineered with a significant decrease in mass (1/8" thick web) and are **extremely susceptible to the effects of fire**. In order to stabilize the building, the joists must be braced with strapping and/or blocking to prevent them from twisting.

Metal C-Joists may come with pre-drilled holes for plumbing and electrical lines. (Figure 8) A newer type of C-Joist, with design characteristics similar to lightweight parallel chord wood truss, has larger openings that allows for the easier running of utilities, and the potential for fire and heat spread is significantly greater. (Figure 9) When exposed to fire and/or high heat, these lightweight steel joists will lose strength and fail rapidly.

A heavy fire and smoke condition on a floor or in the cellar accompanied by little or no smoke condition on the floor or floors above may be an indication of a concrete or gypsum floor poured over corrugated steel (Q-decking) supported by C-Joists. The additional dead load may lead to early floor collapse; caution should be used at fires in buildings with this type of construction.



Figure 8



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Figure 9

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3.4. **Composite Truss**

This type of truss system is similar in design to a lightweight parallel chord wood truss, but comprised of two types of materials: wood and steel. A formed sheet metal web is attached to 2x3" or 2x4" wood chords with nails or sheet metal gang nails. It is commercially known as a "Space Joist".

- Under fire conditions, the composite truss will react the same as other lightweight (wood or metal) trusses, they will lose strength and fail rapidly (Figure 10)




Figure 10

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4. **OPERATIONS**


4.1. General

- Upon arrival, the age of the building and any signs of recent renovations should be included as part of the initial size-up. Lightweight construction must be suspected in newer type buildings and renovations. Prior knowledge and preplans will also provide information on the presence of lightweight construction.
- It is critical that all firefighting units are made aware that a lightweight support system is present. When lightweight construction is suspected, an immediate examination of the ceiling voids shall be conducted as soon as conditions permit. If any type of lightweight system is found at an operation, an immediate notification to the IC is required.
- The IC shall ensure all members on scene are made aware of the presence of lightweight construction. Once discovered, this information shall also be transmitted to the DC 911 dispatcher in the preliminary and/or progress reports so that it can be relayed to responding units.
- Once the fire enters the concealed space containing lightweight trusses or joists, it can rapidly travel to remote locations. The IC shall immediately be notified. All members shall be directed not to enter the fire area or areas directly above the fire until the IC determines the risk of a planned coordinated interior attack. This is especially true with the open-web design of lightweight parallel chord wood and composite trusses.

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Additionally, when heated gases build up in the concealed spaces of the trussloft and attic/cockloft, there is a much greater potential for a backdraft to occur.

- A Thermal Imaging Camera (TIC) should be used to assist in detecting fire and heat in concealed spaces. When inspection holes are made, the TIC should be used to determine if any heat is present in and around metal gusset plates and C-Joists.
- Units operating above the fire should use caution, since the TIC may not always detect the intensity of the fire below. In addition, it may not detect heat or fire where double - 5/8" drywall is used.
- Unless the fire is minor, or confined to a small area, the primary emphasis for a fire in a lightweight building under construction is that of an exterior attack. Exterior streams should be positioned and operated from safe areas outside the collapse zone.
- When fire is found in a vertical void, the cockloft/attic space should be promptly checked for extension within the limits of safety.
- Fire venting out one or more windows may auto-expose onto the outside of the building and into an eave or attic/cockloft vent opening. Also, the soffit area of the eave may be poorly protected by thin plywood and/or plastic soffit board. As a result, an extending fire could rapidly involve the lightweight roof support system. A careful examination must be conducted for extension into these areas.
- A serious fire inside the building may affect the outside deck/balcony supporting members, causing it to fail without warning. When there is any doubt as to its stability, members should not operate on or below the outside deck/balcony.
- When an outside deck/balcony is present, the possibility of outside fires caused by barbecues, outside rubbish, etc. is increased. An exterior fire may extend up the side of the building and into an eave or attic/cockloft vent opening.
- The presence of smoke pushing at the floor line on the outside of a building may be an indication of a fire in a trussloft. When this warning sign is evident at a private dwelling fire, it is an indication that the probability of collapse is significantly increased.
- During overhaul, only the minimum number of firefighters necessary to complete the task should be used. Any floor or roof support system that has been heavily damaged due to fire should be hydraulically overhauled from a safe area using the reach of the

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hose stream. Members should not operate directly above or below the structurally damaged area, including the entire length of the joist.

4.2. **Engine Company Operations**

The positioning of the 1st hoseline for a quick knock-down of a contents fire that has not extended to the structural components is of paramount importance.


- 2nd hoseline must be positioned to back up the 1st, needed to address a potential life hazard or is directed by the IC to a location remote from the 1st hoseline, a 3rd hoseline must be positioned as a back-up line.
- The IC shall special call an additional mutual aid engine company for a structural fire in a building constructed of lightweight materials.

When the fire is of such magnitude that it cannot be quickly knocked down with the two hoselines, then an outside operation must be considered. The operating personnel inside the building must be limited so that quick egress is not impeded.

A serious problem may occur when radiant heat and fire exposes and weakens the floor decking on the floor supporting members. This condition is often discovered when engine company members moving into the immediate fire area suddenly plunge through the floor deck. When the spacing between the light weight floor supports is 24" apart, the potential exists for a larger opening to be formed for members to fall through to the floor below. Caution should be used when entering the immediate fire area until the integrity of the floor deck can be verified.

To avoid concentrating a load in any given area, the engine firefighters must ensure they do not bunch up while operating the hoseline. Only the minimum amount of firefighters necessary to achieve quick knock-down should be operating in the fire area.

Nozzle FFs should use the leg forward method due to the potential of fire and heat weakening the floor system and causing a collapse.

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4.3. **Ladder Company Operations**

When lightweight construction is suspected, members performing ladder company operations shall make an inspection hole in the ceiling from a safe area in order to determine the type of support system present (i.e. for a fire on the 2nd floor, an inspection hole can be made on the 1st floor). This critical task shall be done immediately upon arrival. The IC must be notified of the results of this examination.

When fire is located in the cellar or the first floor and conditions prevent visual identification of the type of construction, an examination could be made in a similar attached exposure. This inspection shall be assigned by the IC to an available unit or personnel.


Before entering any room that was involved in fire, one or more inspection holes shall be made in the ceiling to check for fire extension. Members shall ensure that a charged line is in position before any additional openings are made. The IC must be notified of the results of this examination. After the contents fire is knocked-down, the ceilings, walls, and other concealed spaces should be opened to check for fire extension. The IC must be notified of the results of this examination.

Members should use caution during overhaul of the fire area. The drywall on ceilings and walls provide support within the structure; and indiscriminate removal of large areas could cause instability, particularly in buildings with C-joint construction.

Fire conditions will dictate the feasibility of roof operations, and firefighters should continually evaluate the risks versus the potential benefits. Company Officers must communicate to the Roof firefighter the location and extent of fire in the building.

In order to relieve conditions on the upper floors, the top floor windows shall be vented. However, all exterior ventilation must be communicated and coordinated with the Ladder Company Officer inside the fire area to be vented.

Cutting the roof and pushing down the ceiling could expose the cockloft area to additional heat and fire from the top floor. In addition, a saw cut could sever a structural member causing the

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failure of one or more trusses/joists. Therefore, under no circumstances shall the roof be cut in any peaked or flat roof building of lightweight construction.

When fire conditions are so severe that any additional ventilation would necessitate the roof to be cut, the IC should consider an exterior attack.

When the fire is on the top floor and there is clear indication that the fire has not entered the cockloft, roof operations shall be limited to:

- Checking the rear and sides of the building.
- Venting the top floor windows, and skylights if present
- Inspecting HVAC duct vents for unusual heat.
- All members shall be removed from the roof upon completion of these duties.

When fire is on the top floor and there are indications that it has extended to the attic/cockloft, the IC shall be immediately notified, and members shall not be permitted to operate on the roof. Any fire present in the attic/cockloft represents the potential for a partial or complete collapse of the roof.

Members should use caution when placing an aerial ladder, tower ladder, or portable ladder to a flat roof with a decorative parapet constructed of lightweight materials. The stability of these parapets should be carefully evaluated prior to use as they may not be substantial enough to support the weight of firefighters and/or ladders.


Floor Above Considerations

Before proceeding above the fire floor, members should determine:

- Location, and extent of the fire.
- Presence of a life hazard (known or suspected).
- Position and progress of the 1st and 2nd hoselines.

Due to the collapse potential, operations above the fire floor in a lightweight constructed private dwelling are extremely hazardous. In all cases, fire conditions will dictate the feasibility of floor above operations. A known life hazard on the floor(s) above must be addressed within the limits of safety. Members should continually evaluate the risks versus the potential benefits.

When not already completed by initial members performing Ladder company operations, later arriving members operating on the floor(s) above shall make inspection holes to determine the

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type of construction and the extent of fire in any concealed areas. The IC must be notified of the results of this examination.


Search and Considerations

The importance of conducting search operations in buildings built with traditional construction materials is the same for buildings with lightweight construction. These newer lightweight buildings are more susceptible to collapse from the effects of fire and high heat; and a careful risk-reward evaluation must be conducted to ensure that firefighters are not placed at undue risk. When lightweight components are exposed to fire or high heat, the IC should advise all members not to enter the fire area and the area(s) directly above; a defensive strategy should be strongly considered. It may be necessary to remove members or suspend interior operations until further assessment of structural stability and collapse potential can be made.

Searches must be conducted with consideration that interior operational time will be of limited duration. The only exception is when immediate action must be taken to address a known life hazard. In this situation, risk should be minimized by utilizing only the personnel needed to safely execute the rescue.

Incident Commander

An IC must be thoroughly knowledgeable in fire behavior and building construction in order to make informed and measured decisions at fire operations. Past experience has led to the development of sound practices; and, in particular, rule of thumb guidelines for safe interior operational times. Firefighting tactics and procedures were formulated based primarily upon fires in older buildings built with traditional, ordinary/wood frame construction materials and techniques (i.e. full-dimensional sawn lumber). In these types of buildings, units could safely and routinely operate for a period of time (e.g. VEIS, extinguishment) in the fire area and/or the areas above without the concern of early collapse. In lightweight constructed buildings, an adjustment in strategy and tactics will be required when a fire has progressed from a contents fire to a fire involving structural components. Due to the potential failure and early collapse of these

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lightweight structural components, a proper risk-reward analysis may determine that a planned coordinated interior attack is not justified.

Key size-up indicators for the IC include:

- Extent of the fire. (light, medium, heavy)
- Location of the fire (top floor, cellar, void spaces, etc.)
- Volume of smoke and fire (light, medium, or heavy)
- Smoke action (pushing, twisting, or rolling under pressure)

When size-up determines that the fire involves only the contents and has not extended into the structural components, standard tactics for private dwelling fires are generally appropriate.


As fire conditions dictate, the IC may consider ordering all units to a safe operating area, or completely withdraw from the building. Under certain circumstances, it may be necessary to first knock down the fire from a safe location. Searches may then be conducted after verifying that the support systems are structurally stable enough to safely proceed.

Due to the potential for early collapse, the number of units entering the building during the initial stages of fire operations must be limited. All areas through which hoselines are stretched must be maintained clear and unobstructed to allow for unimpeded positioning and advancement. Operating members must be able to move quickly and safely to an area of refuge should the need arise.

Alternative means of access and egress from all areas of operation should be considered. (e.g. ladder placement, breaching capability)

The IC must be immediately notified of the presence of “Hoarder-type” conditions. Water from hoselines absorbed into the large amounts of debris will substantially increase the weight on the floor. Since the built-in safety factor normally found in traditional, ordinary/wood frame construction is not provided for in lightweight construction, the increased live load may potentially cause a collapse without warning.

The Incident Commander shall be immediately notified of any indications of structural damage (e.g. sagging floors, walls out of plumb) and/or extension of fire to the structural components. The

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Incident Commander shall ensure that all members on the scene are notified of these conditions, and make the necessary adjustments in strategy and tactics.

When implementing an exterior attack and the use of large caliber streams, the weight of the water significantly increases the potential for collapse.

CONCLUSION

The best time to gather information on the specific type of support systems in lightweight buildings is during the construction phase. Members should be cognizant of any new construction or renovation currently underway in their fire district or throughout the county.

Whenever lightweight construction is discovered, members shall:

- Notify an Officer of same

All members shall during an upcoming drill:

- Conduct site familiarization drills during each phase of construction, ex. Framing, HVAC installation, finished drywall; this could enhance critical information to be entered in to preplans.